SECTION 230900 – ENERGY MANAGEMENT SYSTEM AND BUILDING AUTOMATION SYSTEM CONTROL FOR HVAC

PART 1 - GENERAL

1.1 INSTRUCTIONS TO VENDORS

A. Vendor is cautioned that the Owner reserves the right to reject any Vendor, which in the Owner's sole judgment, takes meaningful deviation or exception to Division 23 Direct Digital Control (DDC) Standards. The Charlotte-Mecklenburg Schools' (CMS) Energy Manager and/or designated representative of the Energy Management Department (EMD) shall review all vendor substitution submittals. Vendor substitution approval/disapproval shall be returned via the project architect in writing from Charlotte-Mecklenburg Schools' Energy Manager and designated EMD Project Manager.

B. The overriding requirement is the use of the DDC Control System to maintain design occupant comfort with optimal minimized energy consumption while maximizing equipment, component, and system design function integrity and life.

1.2 RELATED DOCUMENTS

A. Drawings (both mechanical and electrical project manual drawings) and general provisions (within Divisions 23, 26, 27) of the Contract, including General Conditions apply to this Section.

B. The provisions of the General Conditions, Supplementary Conditions, and the Sections included under Division 1, General Requirements, are included as a part of this Section as through bound herein.

C. Sections within Division 23 Mechanical and Division 26 Electrical apply, including though not limited to

D. 1. 23 09 01 – BAS Graphical User Interface Guidelines

E. 2. 23 09 02 – BAS Point Naming and Tagging Guideline

F. 3. 23 29 23 – Variable-Frequency Motor Controllers

G. 6. 23 08 00 – Commissioning of HVAC and BAS

H. 7. 26 08 00 - Commissioning of Electrical Systems

I. 9. 23 09 93 – Sequences of Operation for HVAC controls

1.3 SUMMARY

A. This Section includes Energy Management and Remote Automated Computer Control Systems for HVAC and Lighting systems and components, including control components for terminal heating and cooling units including approved integration with factory-wired controls. The work of this section 23 09 00 shall be provided by the Building Automation Systems controls contractor.

B. The Building Automation System (BAS) Controls shall be comprised of a Direct Digital Control (DDC) network of interoperable, stand-alone digital controllers communicating on a BACnet communication network over IP across the CMS network to CMS owned virtual server hosting the Web Supervisor(s).

C. The system shall provide the Direct Digital Control (DDC), Energy Management and Building Automation System (BAS) for the air conditioning, heating and ventilating systems, lighting controls and

shall interface with other microprocessor-based building subsystems as shown on the drawings and as specified.

1.4 ABBREVIATIONS AND ACRONYMS

A. AHU: Air Handling Unit

B. AI: Analog Input

C. ANSI: American National Standards Institute

D. AO: Analog Output

E. ASC: Application Specific Controller

F. ASHRAE: American Society of Heating, Refrigerating, and Air Conditioning Engineers

G. ASPE: American Society of Plumbing Engineers

H. ASME: American Society of Mechanical Engineers

I. ASTM: American Society for Testing and Materials

J. ATC: Automatic Temperature Control System

K. AWG: American Wire Gauge (Standard)

L. BACnet/IP, BACnet/MSTP: Acceptable Communication Protocols across the EMS/BAS Controls Network.

M. BAS: Building Automation System

N. BI: Binary Input

O. BMS: Building Management System

P. BO: Binary Output

Q. CAD: Computer Aided Design

R. CCC: Central Communications Controller

S. CCU: Central Control Unit

T. CPU: Central Processing Unit

U. CRT: Cathode Ray Tube

V. DALI: Digital Addressable Lighting Interface

W. DCP: Digital Control Panel

X. DDC: Direct Digital Controls

Y. DI: Discrete Input

Z. DMA: Direct Memory Access

AA. DMZ: Demilitarized Zone Network

BB. DO: Discrete Output

CC. EMS/BAS: Energy Management System / Building Automation System

DD. FAC LAN: Facility Local Area Network

EE. FACP: Fire Alarm Control Panel

FF. FCC: Fire Command Center

GG. FCIP: Fire Fighters' Control and Indicating Panel

HH. FMS: Facility Management System

II. GUI: Graphical User Interface

JJ. HTML5: Hyper Text Markup Language 5

KK. HVAC: Heating Ventilating and Air Conditioning

LL. I/O: Input/output.

MM. IP: Internet Protocol

NN. ISA: Intelligent Sensor or Actuator

OO. MS/TP: Master Slave/Token Passing

PP. MSCP: Mass Storage Control Protocol

QQ. MSI: Master System Integrator

RR. NC: Network Controller

SS. NCP: Network Control Panel

TT. NEC: National Electric Code

UU. NI: Network Integrator

VV. NIC: Not in Contract

WW. NPBI; Needle Point Bipolar Ionization

XX. NFPA: National Fire Protection Association

YY. NSS: Network Services Server

ZZ. NSI: Network Services Interface

AAA. OS: Operating System

BBB. PCU: Programmable Control Unit

CCC. PID: Proportional Integral Derivative

DDD. PRV: Pressure Reducing Valve

EEE. RAM: Random Access Memory

FFF. ROM: Read Only Memory

GGG. RTD: Resistance temperature detector

HHH. SCADA: Supervisory Control and Data Acquisition System

III. SI: Systems Integrator

JJJ. SNVT: Standard Network Variable Type

KKK. SPACE; A complete ventilation path as defined by ASHARE

LLL. TCP/IP: Transmission Control Protocol / Internet Protocol

MMM. THHN: Thermoplastic High Heat Resistant Nylon Coated-Cable Coating

NNN. TP: Twisted Pair

OOO. UL: Underwriters Laboratory

PPP. UML: Unified modeling Language

QQQ. UPS: Uninterruptible Power Supply

RRR. VAV: Variable Air Volume

SSS. VCS: Voice Communication System

TTT. VFD: Variable Frequency Drive

UUU. XML: Extensible Markup Language

VVV.

WWW.

XXX.

1.5 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphical information at the present day fastest refresh interval capable by the most current updated graphical software revisions within the confines of the firmware of the connected equipment.
2. Graphic Refresh: Display information at the fastest refresh interval of the most recent graphical software revision within parameters of the workstation.
3. Object Command: Reaction time shall be at the fastest refresh interval with the most current up-to-date graphical software version within the firmware capabilities of the connected equipment. In no case shall that be more than two seconds between operator command of a binary object and device reaction.
4. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
5. Reporting Accuracy and Stability of Control: Report values and maintain measured variables to within industry standards and tolerances no greater than those as follows:
    a. Space Temperature: Plus or minus 1 deg F.
    b. Ducted Air Temperature: Plus or minus 1 deg F.
    c. Outside Air Temperature: Plus or minus 2 deg F.
    d. Dew Point Temperature: Plus or minus 3 deg F.
    e. Temperature Differential: Plus or minus 0.25 deg F.
    f. Relative Humidity: Plus or minus 5 percent.
    g. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
    h. Airflow (Terminal): Plus or minus 10 percent of full scale.
    i. Air Pressure (Space): Plus or minus 0.01-inch wg.
    j. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
    k. Carbon Monoxide: Plus or minus 5 percent of reading.
    l. Carbon Dioxide: Plus or minus 50 ppm.
    m. Electrical: Plus or minus 5 percent of reading.

1.6 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, options provided, finishes for materials, and installation and startup instructions for each type of product indicated.
1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
2. Control System Software: Include technical data for operating system software, operator interface, color graphics, programming, sequence of operations, and other third-party applications.
3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and specific location and size of each assembly and field connection.
1. See paragraph 2.3.A.2 for digital storage of controls shop drawings as-builts and product data sheets.
2. Bill of materials of equipment indicating quantity, manufacturer, and model number.
3. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
4. Wiring Diagrams: Power, signal, and point to point control wiring.
5. Details of control panel faces, including controls, instruments, and labeling.
6. Written description of sequence of operation for each system and component.
7. Schedule of dampers including size, leakage, and flow characteristics.
8. Schedule of valves including flow characteristics.
9. DDC System Hardware:

a. Wiring diagrams for control units with enumerated termination numbers.
b. Schematic diagrams and floor plans for field sensors and control hardware.
c. Schematic diagrams for point-to-point control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

10. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, pdf links, and operator notations.
11. Controlled Systems:
    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically and geographically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagrams in pdf to be embedded on graphical screens.
    d. Points list with corresponding controller ID's.
12. Submittal of graphical interface and graphical representations of each component.

C. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Maintenance instructions and lists of spare parts for each type of control device.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.
6. Normal, range and failsafe position for each device.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative, who is trained and approved for installation of system components required for this Project, and who employs only factory trained personnel, with minimum experience as follows:
1. Firm: Ten years.
2. Project Manager: Five years.
3. Project Engineer, Application Engineering Staff: Three years.
4. Electronic Technicians: Two years.

B. Approved manufacturers shall have minimum three full-time factory trained and certified service personnel located within twenty-five miles travel distance of CMS Building Services.

C. Comply with ANSI/ASHRAE Standard 135-1995 for DDC system components for BACnet MSTP at the unit controller level.

D. Controls equipment and components shall meet or exceed the following standards: UL-916; Energy Management Systems (EMS).

E. Preinstallation Conference: Including Architect, Owner's representative, and affected Installers, to review approved submittals and installation strategies.

1.8 QUALIFICATION REQUIREMENTS

A. The EMS/BAS controls contractor must have a minimum of 10 years of experience manufacturing and installing the controls system similar in performance to that specified herein and shall be prepared to evidence this history as condition of acceptance and approval prior to bidding.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Delivery of material shall not be considered complete until installed. Components shall be protected from detrimental environmental conditions until mounted at the component's final location.

B. Storage shall be at the contractor's risk and responsibility in collaboration with the Owner.

C. All material handling shall remain the contracts responsibility.

D. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

1.10 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with owner, plans and room details before installation. All field installed components shall remain accessible for maintenance and repair.

B. Coordinate equipment with Division 26 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system. Provide LED RIB Relays or approved devices for demarcation between 3rd party systems. Label all devices with function.

C. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

D. Coordinate equipment with Electrical requirements Section "Panelboards" to achieve compatibility with starter coils and annunciation devices, VFD's, Lighting Controls and annunciation devices. Provide LED RIB Relays or approved devices for demarcation between 3rd party systems. Label all devices with function.

E. Global site controllers shall have dedicated power circuits, with UPS and Emergency Generator backup.

F. All work with trades for 3rd party devices and equipment that are to be supplied and or interfaced "by others.".

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Existing Rivergate Elementary has an ALC DDC system. New Rooftop equipment must be fully integrated and functional with the existing facility.

B. Manufacturers approved as listed below, each having critically defined data made available and integrated via BACnet/MSTP to CMS's existing ALC web control:
1. Automated Logic's (ALC) WebCTRL as provided by Automated Logic – North Carolina, Charlotte, NC.

C. Comply with qualification requirement in above sections 1.7 and 1.8.

D. Pre-approval does not relieve the manufacturer from compliance of 23 09 00.

2.2 CONTROL SYSTEM

A. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems. System must be hardwired controllers, and field devices, wireless, or IP addressable when approved.

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on BACnet network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.3 GENERAL

A. The Building Automation System (BAS) shall include but not be limited to the following components.
1. The BAS Operator Interface shall be accessible from any internet browser using HTML5 current technology via Windows 10 or greater OS from Microsoft Edge, Google Chrome, and/or Mozilla Firefox, and/or a mobile app. The Global Operator Interface is a graphical display providing efficient and effective navigation across multiple platforms initially thru a higher-level CMS designated single web supervisor frontend with navigation capabilities to and thru any one of the CMS five vendor specific secondary level frontends. The BAS Operator Interface consists of hardware and software that allows full user monitoring, adjustment of system parameters, fault detection and diagnostic capabilities. The systems shall support an unlimited number of passwords protected concurrent users, if view only, and shall be individually identifiable if provided with command and control.
2. Digital storage of as-built control drawings and product data sheets including sequences of operation, and relevant project manual as-built drawings/information shall be in pdf format; stored on the virtual server; and made accessible from the site front page via a navigation link. BAS Drawings and product data sheets pdf are to be stored in the BAS by the building automation controls contractor. Drawings and other project information electronic pdf are to be provided by others and stored and made accessible in the BAS by the Controls Contractor.
3. System Level Controllers shall manage the Energy and Building Management capabilities of the automation system as well as facilitate remote communications and central monitoring.
4. Application Specific Controllers shall provide distributed, pre-engineered control, specific to the mechanical equipment specified.
5. Custom Application Controllers with distributed custom programming capability shall provide control for nonstandard control sequences.
6. The Data Communications capability shall allow data to be shared between the various controllers in the architecture.
7. The system software shall include system software for global application functions, application software for distributed controllers, and operator interface software.
8. End devices such as sensors, actuators, dampers, valves, and relays. AI/AO DI/DO's must be compatible and afforded isolation/protection from 3rd party devices.
9. All 3rd party controllers read, write, AV/BV values shall be BACnet compatible. All non-vendor specific controllers shall be preapproved by CMS.

B. The failure of any single component shall not interrupt the control strategies of other operational devices. System expansion shall be through the addition of end devices, controllers, and other devices described in this specification.

C. Hard wired Safety circuit end of line devices shall reside in the same controller as the equipment being protected.

D. All Controllers shall automatically reboot and retain system properties programming and settings in the event of a power failure.

2.4 DDC EQUIPMENT

A. Only CMS authorized and configured computers by Building Services Support Services Technology Group are permitted. All required software for the BAS Controls and DDC system diagnostics shall be loaded onto multiple CMS computers, compatible with current CMS technology. All necessary operational and utility software to operate, configure, maintain, program, trend, perform diagnostics, override control points, and edit graphics shall be provided and reside on the server. No annual renewal fees shall be required on software.

B. Building Controls Contractor shall coordinate with Owner's IT department to interface with the local demilitarized zone (DMZ) network. The DMZ subnetwork is logistically located between the public internet and private networks. The contractor shall be responsible to coordinate the security of the Building Automation System's network.

2.5 BUILDING AUTOMATION FUNCTIONS

A. System Graphics. The BAS panel shall serve up HTML5 type data and standard equipment graphics pages arranged alphabetically by school/facility. No special software on any remote computer shall be required to view/edit the graphics. IT connectivity shall be provided by Owner. The BAS GUI shall also have navigation tree. Provide a standardized and consistent method in conjunction with existing navigation for the operator to easily move between graphic displays. See section 230901 for information on Graphical User Interface and Tree and Branch Layouts.

B. Data on web pages must be returned and updated on a given web page at the maximum interval the control processor can deliver but no less than 5 seconds.

C. System Applications. Provide the following applications:
1. Area Control: Area application coordinates HVAC equipment for a specific area of the building. The application shall assign unit controllers, binary outputs, and binary values to be members of a common area to efficiently perform a single operation (such as changing a setpoint, creating a schedule, performing an override) and apply it to all members of the area. In addition, the area application shall use algorithms, along with area temperatures and humidity inputs, to make an economizing decision. The application shall also include optimal start/stop, humidity pulldown, night purge, unoccupied heating/cooling, unoccupied humidify, unoccupied dehumidify, and timed override functions.
2. The Variable Air Systems: (VAS) application coordinates air-handling units, variable-air-volume (VAV) boxes, and ventilation within a building. VAV units are assigned to the air-handling unit that supplies air to them. The VAS application coordinates the start-up and shut-down of the system to ensure proper static pressure control.
3. Integration: Energy-saving applications, including static pressure optimization and ventilation optimization, are required features. Control sequences of dedicated primary pumps shall be provided by the dedicated primary system served, (e.g. Boilers, Chillers, etc.) BAS DDC functionality can be supplemented with BACnet connections for feedback provided stand alone and local capabilities, and Safety sequences are not compromised. Safety circuits should not be wired through the BAS.
4. Reports features: The operator interface shall provide a reporting package that allows the operator to select reports. Standard reports for equipment shall be made available from the BAS. These reports provide a valuable source of data that can be used for record-keeping and troubleshooting.
5. Report types shall include: Site reports, VAS commissioning reports, All Points in Alarm Report: Provide an on demand report showing all current alarms, All Points in Override Report: Provide an on demand report showing all overrides in effect, Points report: Provide a report that lists the current value of all points, the operator interface shall provide a reporting package that allows the operator to select reports, the operator interface shall provide the ability to schedule reports to run at specified intervals of time. The operator interface shall allow a user to export reports and logs

from the building controller in a format that is readily accessible by other standard software applications including spreadsheets and word processing.

6. System Diagnostics: The BAS shall automatically monitor and report the operation and condition of all network connections, building management panels, and controllers. High level notification of critical alarms will be reported and displayed at the Global N4 Tridium Single-Entry initial navigation page from all CMS EMS/BAS control platforms. On the Global page, all CMS sites will be listed in alphabetical order and have the following summarized notification of 3 critical alarms:
    a) Network Comm/Site's BAS Controller Down,
    b) Site Mechanical Plant Chiller, Boiler, Ancillary Equipment Down,
    c) NPBI Module Non-Functional
7. Override Point Control: Provide a tracked method for a user to view, override, and edit if applicable, the status of any object and property in the system. The point status shall be available by menu, on graphics or through custom programs. A summary log of all Overrides, the point(s) overridden, by whom, when, for how long shall be on the BAS front end, and all override shall have a default "TEMPORARY-TIMED-OPTION" with an automatic return to the designed setting parameter. Permanent operator overrides shall only be assigned with high level password access.
8. Override Owners: The system shall convey to the user the owner of each override for all priorities that an override exists. Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.
9. Datalogs; Provide Data logs for each major piece of equipment (chillers, boilers, air handling units, rooftop units, and pumps) by School. Temperature sensors in IDF/MDF rooms shall also be trended. Logs shall be capable of being viewed in real-time, or at a later time (historical data) in graphical and tabular format. They shall also be capable of being printed and saved. With the proper security access, system users can configure (create, delete, and update) and manage (clear, enable, and disable) data logs in the system. Each point in the data log should clearly be delineated by color and key in a multiple simultaneous per data log capability. The operator interface shall allow a user to export trend log data in CSV or PDF format for use by word processing and spreadsheet packages such as Microsoft Office Word and Excel. Data logs shall be able to be stored for up to three years.
10. Scheduling: Schedules by ventilation space (e.g. AHU, RTU, DX) and/or groups of zones (e.g. Multiple Buildings, Schools, Event sites, etc.) shall be programmed into the system at owner turnover, confirmed during owner training. A user shall be able to perform the following tasks utilizing the operator interface: Edit an existing schedule; Create a new schedule; Defining the default values, events and membership; Create exceptions to a schedule for any given day, and/or hours within a day; Apply an exception that spans a single day or multiple days, independent or consecutive; View a schedule by day, week and month with exceptions, schedules, and holidays characterized and shown clearly a calendar format. Modify the schedule events, members and exceptions. Scheduling should be able to be deployed and integrated to by facility-type (ES, MS, HS, Admin, et al), basis from the BAS and the N4 Tridium High level frontend GUI. Overlapping schedules shall be clearly indicated and displayed.
11. Alarm/Event Notification: An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon. A display of the last Alarm and counter of the same previous alarms in history is preferred.
12. Alarm/Event Log: The operator shall be able to view all logged system alarms/events from any operator interface. The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 4 categories based on severity. Alarm/event messages shall use full language, easily recognized and consistent descriptors. An operator with the proper security level may acknowledge and clear alarms/events. All alarms/events that have not been cleared by the operator shall be stored by the building controller. The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.
13. Alarm Processing: Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system. If an alarm exists, an alarm shall be uniquely visible in the GUI and

Global navigation bars (N4 & Vendor Platforms). The data displayed in the log includes when and where the event occurred and whether the operator is required to acknowledge it. An operator shall also have the capability to use the log to add comments about events. Column headings can be used to sort and filter events. They shall also be available to be removed or exported from the log.

14. Alarms and Events: log shall contain multiple categories that can be used to sort and filter them. Sorting shall be based, for example, on severity level. Filtering shall be used to view only the alarms from a specific piece of equipment, or space, or those received at a specific time or from a specific alarm category.
15. Security: Each operator shall be required to login to the system with a unique username and password to view, edit, add, or delete data. Multiple User Profiles shall be provided to restrict the user to only the objects, applications, and system functions as assigned by the system administrator. User logon/logoff attempts shall be recorded. The system shall protect itself from unauthorized use by automatically logging off after a predetermined adjustable time following the last keystroke. The delay time shall be administrator definable by log in.
16. Pre-defined Profiles: The system shall include pre-defined profiles that allow a system administrator to quickly assign levels of permissions to a user or group of users.
17. Help; Provide a context sensitive, online help system to assist the operator in navigation and configuration of the system. On-line help step by step shall be available for all system functions and shall provide the relevant data for each particular screen.
18. Network Monitoring: The system shall automatically monitor the operation of all network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operators and geographically depict the fault location.
19. The building automation system (BAS) shall provide the ability to initiate the auto-commissioning/auto-calibration command directly from the user interface. Special service tools shall not be required. The terminal boxes shall allow the operator to perform on an individual or group basis auto-commissioning report for the VAV box which contains the results of the auto-commissioning/auto-calibration tests which is printable and remain in memory until the next auto-commissioning test is initiated. This report shall contain, at a minimum, the following information for each VAV box in the system. Name of terminal box. Date and time the terminal box was tested. Presence of any alarms. Space temperature and set-point. Active airflow (in CFM). Air valve/damper position when the terminal box reaches 40 percent of the maximum cooling airflow set-point. Air valve / damper position when the terminal box reaches 100 percent of the maximum cooling airflow set-point. Discharge air temperature (if specify on points list) of the terminal box when the terminal local fan is off. Discharge air temperature of the terminal box when the terminal local fan is on. Discharge air temperature of the terminal box when the hot heat is active.
20. Controls contractor shall provide commissioning agent all controls software at no additional cost.

2.6 ARCHITECTURE/COMMUNICATIONS

A. This project shall be comprised of a high-speed Ethernet network utilizing BACnet/IP communications between System Server, Controllers and Workstations. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall utilize BACnet/IP (owner preferred) or wireless communications.

1. Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet protocol as prescribed by the BACnet standard. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all controllers within the system.

2.7 SYSTEM LEVEL CONTROLLERS

A. System level controller shall reside on the CMS enterprise-Wide Area Network (WAN). The enterprise WAN is provided by the owner and supports the Internet Protocol (IP). Local Area Network connections for the Building Controllers shall be provided by the controls contractor on ISO 8802-3 (Ethernet). Each

Building Controller shall also perform routing to a network of Custom Application and Application Specific Controllers. Each Building Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet MSTP. Each System Controller shall be listed as a Building Controller (B-BC) by the BACnet Testing Lab.

B. System level controller shall support hardwire communications to equipment level direct digital controllers. Multiplexing of receivers and transmitters is not acceptable.

C. Each System Level Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all BACnet/MSTP controllers within the system.

D. The System Level Controller shall have ample memory to support its operating system, database, and programming requirements. All trending history shall be stored at the system level controller for 48 hours and then automatically downloaded to the CMS server.

E. The System Level Controller shall store database and programming files.

F. The operating system of the System Level Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.

G. Data shall automatically be shared between System Level Controllers when they are networked together. All System Controllers shall have a real time clock.

H. The database and custom programming routines of remote System Level Controllers shall be editable from a single operator station.

I. The System Level Controllers shall have the capability of being remotely monitored over LAN. Additional capabilities shall include automatically sending out alarms, gathering alarms, reports and logs, programming and downloading databases.

J. The controller shall continually check the status of all processor and memory circuits. If a failure is detected, the controller shall:
   1. Assume a predetermined fail-safe failure mode.
   2. Emit an alarm condition, displaying visually on graphics and/or audibly, and/or via email or SMS.
   3. Create a retrievable file of the state of all applicable memory locations at the time of the failure unless latched.
   4. Automatically reset the System Controller to return to a normal operating mode.
   5. Automatically reboot with all programming and memory function intact upon a voluntary or involuntary power cycle.

K. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure and shall be rated for operation at -40 C to 50 C [-40 F to 122 F].

2.8 EMS/BAS APPLICATION SPECIFIC CONTROLLERS

A. Application Specific Controllers shall be stand-alone, microprocessor based Direct Digital Controllers with sufficient memory to handle its operating system, database, and programming requirements of the BAS. These controllers are assumed to be used for air handling units, chillers, etc.

B. The Application Specific Controller shall be pre-programmed, tested, and factory mounted on the mechanical equipment to ensure reliability. Where factory mounting is not possible, the controllers shall be factory programmed and tested prior to shipment to the jobsite. The controllers shall be clearly

labeled as to controller type, where it is to be installed, and software address (if applicable). The controller shall be fully tested upon installation to ensure that it is properly matched to the equipment it is controlling.

C. The controller shall communicate with other devices on the communication network and be fully integrated with the other system components.

D. BACnet Application Specific Controller (ASC) shall provide I/O points based on the points list to fulfill the sequence of operation section of this specification manual. BACnet Unitary application specific controllers shall provide I/O points based on the points list in the sequence of operation section of this specification manual. The controller shall include, as required by the points list or sequence of operation, two of each additional AI/AO/BI/BO points beyond what is shown on the points list.

E. The hardware shall be suitable for the anticipated ambient conditions.
1. Controllers used outdoors or in wet ambient shall be mounted within waterproof enclosures, and shall be rated for operation at minus 40 to 155 degrees F.
2. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32 to 120 degrees F.

F. The ASC unit controller shall be dedicated for each ASC unit, with one single processor to handle all points specified.

2.9 EMS/BAS CUSTOM APPLICATION CONTROLLERS

A. The Custom Application Controllers shall provide stand-alone control and require no additional system components for complete operation. It shall have sufficient memory to support its operating system, database, and programming requirements. The controller shall communicate with other devices on the communication network and be fully integrated with the other system components. All controllers shall be BACnet BTL listed communications MSTP.

B. BACnet Programmable controller shall have built-in I/O points based on the points list in the sequence of operation section of this specification manual. All programming required for operation shall be memory resident and shall be retained in permanent memory.

C. The Custom Application Controller shall be configured such that the Portable Operator Interface can be plugged directly into it or within sight for programming, editing, and other operator functions.

D. Controller hardware shall be suitable for the anticipated ambient conditions.
1. Controllers used outdoors or in wet ambient shall be mounted within waterproof enclosures, and shall be rated for operation at minus 40 to 155 degrees F.
2. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32 to 120 degrees F.

2.10 CONTROLLERS SOFTWARE PROGRAMMING, CONFIGURATION, SERVICE TOOL

A. Provide one copy of software programming and service tool that is specifically compatible with the BACnet unit level controllers. This software shall be registered and shall be property of the Owner at project completion. This software tool shall not have installer license restriction that prevents the Owner or his servicing agent from use of the tool. The software tool shall not require annual subscription or renewal fees.

B. The software service tool shall be installed on Owner’s provided computer and transferrable to any other CMS.computer.

C. The software service tool shall have the ability to perform the following tasks:
1. View Controller status.
2. View status of points and alarms.
3. Create, edit and override points.
4. Configure and commission System, Application Specific and Custom Programmable controllers.
5. View data logs.
6. Download configuration files, logic program files, and firmware.
7. Upload programs.
8. Backup and restore firmware, configuration files, and logic program files.
9. Create and edit graphics.
10. Modify existing control program.
11. Add new points and edit database.

2.11 INPUT/OUTPUT INTERFACE

A. Hardwired inputs and outputs may tie into the system through System Application, Custom Application, or Application Specific Controllers. Slave devices are also acceptable. Any critical points requiring immediate reaction shall be tied directly into the controller hosting the control software algorithm for the critical function.

B. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall be compatible with commonly available control devices. All status points shown on the point list shall be positive proof differential pressure or current sensing binary switches.

C. Analog inputs shall allow the monitoring of low voltage, current, or resistance signals and shall have a minimum resolution of 0.1 percent of the sensing range. Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.

D. Binary outputs shall provide a continuous low voltage signal for on/off control of remote devices.

E. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC or a 4 to 20 MA signal as required to provide proper control of the output device.

F. Universal and pulse inputs shall be supported.

G. System architecture shall allow for point expansion in one of the following ways:
1. The addition of input/output cards to an existing System Application Controller.
2. A slave controller may be used to expand point capacity.

2.12 AUXILIARY CONTROL DEVICES

A. Motorized dampers: Ruskin or approved equal, unless otherwise specified elsewhere, shall be as follows.
1. The Building Automation System supplier shall provide all automatic control dampers not specified to be supplied integral to the HVAC equipment.
2. Dampers shall be high velocity low leakage as specified in the sequence of operations. All proportional dampers shall be opposed blade type. Two position dampers may be opposed or parallel blade type.
3. Damper frames and blades shall be galvanized steel and a minimum of 16 gauge. Blade width shall not exceed 8 inches. Dampers and seals shall be suitable for temperature ranges of minus 50 to 250 degrees F.
4. High Velocity Low Leakage Dampers; All dampers shall be low leakage dampers. Field replaceable edge and end seals shall be installed along the top, bottom, and side of the frame and each blade. Seals and bearings shall be suitable for temperature ranges from minus 40 to 200 degrees F. Leakage shall not exceed 6 CFM/SF at 4 inches WC differential. High Velocity Low Leakage dampers shall be Ruskin, Model CD60 or equal.

B. Electric damper actuators: Belimo.
   1. Damper actuators shall be electronic, spring return, low voltage (24VAC) and shall be properly sized so as to stroke the damper smoothly and efficiently throughout its range. Actuator response shall be linear in response to sensed load. End of each damper rod shall be permanently-scored so as to indicate physical position of damper blades. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
   2. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Unless noted in the sequence of operation or utilized for outside air, for VAV box, Unit Ventilators, Fan Coil Units or terminal units, floating actuator fail in place is permitted. VAV boxes may be as provided by controls MFG if Belimo actuator is integrated into the MFG's controller provided parts are fully interchangeable.
   3. Outside air dampers shall fail close. Return air damper shall fail open. Relief damper shall fail close.
   4. All Outside Air, Relief Air and Return Air damper actuators associated with units that have static safety pressure switches shall have position proving switches or blade switches.
   5. All dampers shall be equipped to allow manual override.

C. Control Valves: Belimo,
   1. Control valves shall be two-position isolation or modulating service as scheduled or shown. Valves 1/2" through 2" shall be forged brass body, stainless steel ball and stem, PTFE seat, EPDM packing, equal percentage flow. Valves 2-1/2" and larger shall be cast iron body, bronze seats, stainless steel stem, bronze plug, no lip packing, ANSI class 125, leakage class III, flanged end fitting.
   2. Body, trim style and materials shall be per manufacturer's recommendations for design conditions and service shown.
   3. Isolation valves shall be line size full port, 2 position control.

D. Chilled water valves shall fail to 50% open except as allowed in paragraph D.6 below. Hot water valve shall fail open except as allowed in paragraph D.6 below. Electric valve actuators: Belimo, fully integrated into actuator.
   1. Valve actuators shall be electronic, low voltage (24VAC), and properly selected for the valve body and service. Actuator shall have clutch or gear operator for manual operation.
   2. No more than one pipe size body reduction shall be permitted for hydronic coils.
   3. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
   4. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
   5. Actuators shall be provided with a conduit fitting and a minimum 3 foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
   6. Unless noted in the sequence of operation, for VAV box, Unit Ventilators, Fan Coil Units or terminal units, floating actuator fail in place is permitted.

E. Temperature Sensors: Kele, or approved equal
   1. Temperature sensors shall be Thermistor type 10kohm as dictated by the requirements of this specification. Thermistors are acceptable for space temperature sensors and other monitoring only points.
   2. AHU unit sensors shall be averaging as specified in the sequence of operations. Averaging sensors shall be a minimum of 6 feet in length. For existing application or where installed ductwork exterior to the AHU, duct sensor 12" probe is acceptable.
   3. Averaging sensors shall be 3x3 sq-ft per linear foot of sensor.

4. Immersion sensors shall be provided with a separable stainless steel well. Immersion sensor probe length shall be sized to meet pipe diameter requirements. MFG Thermal lubricant shall be provided.
5. Space sensors shall be flat-plate type sensors. Accuracies shall be plus or minus 1 degree F.

F. Flow and Status Switches: Kele, JCI, Trane, Veris
1. Current sensing relays may be used for flow sensing or terminal devices, as shown. Current-operated switches shall be self-powered, solid state with adjustable trip current. The current switches shall be selected to match the current and electrical characteristics of the equipment being monitored and ~~of~~ the application and output requirements of the DDC system.
2. Paddle type switches (water service only) shall be UL listed, SPDT snap-acting with pilot duty rating (125 VA minimum). Adjustable sensitivity with NEMA 1 Type enclosure unless otherwise specified.
3. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 Type enclosure, with scale range and differential suitable for intended application, or as specified. Water Differential Pressure Switches and shall be installed with full port isolation valves and gauge test ports and made fully accessible or piped to an area where access is afforded without the use of scaffolding or a lift.

G. High Limit Thermostats: Kele, or approved equal High limit thermostats shall be manual reset type set at 120 degrees F.

H. Low Limit Thermostats and Line Voltage Thermostat: Kele, or approved equal.
1. Safety low limit thermostats shall be vapor pressure type with 1 sq-ft coil area per foot of capillary. Element shall respond to the lowest temperature sensed by any one foot section.
2. Low limit shall be DPDT manual reset only rated for the application
3. Where required multiple low limit thermostats shall be installed.
4. Low-Voltage Space Thermostats shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented cover.
5. Line-Voltage Space Thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented cover.

I. Carbon Dioxide (CO2) Sensors: E+E Elektronik, or approved equal
1. Carbon Dioxide sensors shall measure CO2 in PPM in a range of 0-2000 ppm. Accuracy shall be +/- 3% of reading with stability within 5% over 3 years. Sensors shall be outside, duct or space mounted as indicated in the sequence of operation.

J. Interface High Voltage/Current Control Relays: RIB or approved equal
1. Control relays shall be UL listed. Contact rating, configuration, and coil voltage suitable for application.
2. Control relays shall be provided with LEDs to indicate status of the coil.
3. Current sensing relays shall be split core.
4. Time delay relays shall be UL listed dry contact input. Delay shall be adjustable plus or minus 200% (minimum) from set-point shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 Type enclosure when not installed in local control panel.

K. Static/Differential Pressure Sensors: Kele, Veris or approved equal
1. Sensor shall have linear output signal. Zero and span shall be field-adjustable.
2. Sensor sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.

3. Water pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Sensor shall be complete with 4-20 mA output, required mounting brackets, and block and bleed valves. Mount in location accessible for service.
4. Water differential pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (DP) and maximum static pressure shall be 3,000 psi. Transmitter shall be complete with 4-20 mA output, required mounting brackets, and five-valve manifold. Mount in a location accessible for service.
5. Air static or differential pressure sensor shall have range appropriate for their application.
6. Wet Differential Pressure Sensors and transducers shall be installed with full port isolation valves and gauge test ports and made fully accessible either in a mechanical room or within 24" of an accessible ceiling.

L. Humidity Sensors: Kele, or approved equal
1. Duct and room sensors shall have a sensing range of 20% to 80% with accuracy of ±3% R.H. Outdoor air humidity sensors shall have a sensing range of 20% to 95% R.H. It shall be suitable for ambient conditions of -40° C to 75° C [-40° F to 170° F].
2. Duct sensors shall be dedicated duct-mounted probe type.
3. Humidity sensor's drift shall not exceed 1% of full scale per year.

M. Water Flow Metering - Onicon or approved equal
1. Magnetic Water flow measuring sensor shall be Onicon F-3500 series dual turbine.

N. Air Flow Station for Fan Inlet Air Flow Measuring Stations - Ebtron or approved equal
1. Airflow Station: plus/minus 5% accuracy down to 15% nominal flow. Air flow station to be provided by building automation supplier. Provide air flow station only if shown on controls flow diagram or if required by sequence of operation.
2. At the inlet of each fan and near the exit of the inlet sound trap, airflow traverse probes shall be provided that shall continuously monitor the fan air volumes and system velocity pressure.
3. Each traverse probe shall be of a dual manifolded, cylindrical, type 3003 extruded aluminum configuration, having an anodized finish to eliminate surface pitting and unnecessary air friction. The multiple total pressure manifold shall have sensors located along the stagnation plane of the approaching airflow. The manifold should not have forward projecting sensors into the air stream. The static pressure manifold shall incorporate dual offset static tops on the opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as + 20° in the approaching air stream.
4. The airflow traverse probe shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presence in the air stream. Each airflow-measuring probe shall contain multiple total and static pressure sensors placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes utilized at each installation shall comply with the ASHRAE Standards for duct traversing.
5. Remote indication is not required if CFM can be displayed on the building automation system.

O. Air Flow Station for Single Probe Air Flow Measuring Sensor – Ebtron Gold Series or approved equal
1. Airflow Station: plus/minus 5% accuracy down to 15% nominal flow. Air flow station to be provided by building automation supplier. Provide air flow station only if shown on controls flow diagram or if required by sequence of operation.
2. The single probe airflow-measuring sensor shall be duct mounted with an adjustable sensor insertion length of up to eight inches. The transmitter shall produce a 4-20 mA or 0-10 VDC signal linear to air velocity. The sensor shall be a hot wire anemometer and utilize two temperature sensors and a heater element temperature. The other sensor shall measure the downstream air temperature. The temperature differential shall be directly related to airflow velocity.
3. Remote indication is not required if CFM can be displayed on the building automation system.

P. Air Flow Station for Duct Air Flow Measuring Stations - – Ebtron Gold Series or approved equal

1. Airflow Station: plus/minus 5% accuracy down to 15% nominal flow. Air flow station to be provided by building automation supplier. Provide air flow station only if shown on controls flow diagram or if required by sequence of operation.
2. Each device shall be designed and built to comply with, and provide results in accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of fundamentals, as well as in the Industrial Ventilation Handbook.
3. Airflow measuring stations shall be fabricated of 14-gauge galvanized steel welded casing with 90 Deg. connecting flanges in configuration and size equal to that of the duct into which it is mounted. Each station shall be complete with an air directionalizer and parallel cell profile suppressor (3/4" maximum cell) across the entering air stream and mechanically fastened to the casing in such a way to withstand velocities up to 6000 feet per minute. This air directionalizer and parallel cell honeycomb suppressor shall provide 98% free area, equalize the velocity profile, and eliminate turbulent and rotational flow from the air stream prior to the measuring point.
4. Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be placed on each unit casing, listing model number, size, area, and specified airflow capacity.
5. Remote indication is not required if CFM can be displayed on the building automation system.

Q. Transformers and Power Supplies.
1. Control transformers shall be UL listed, Class 2 current-limiting type, or shall be furnished with resettable over-current protection in both primary and secondary circuits for Class 2 service.
2. Unit output shall match the required output current and voltage requirements. Current output shall allow for a 50% safety factor. Output ripple shall be 3.0 mV maximum Peak-to-Peak. Regulation shall be 0.10% line and load combined, with 50 microsecond response time for 50% load changes. Unit shall have built-in over-voltage protection. Unit shall be UL recognized.
3. Controller Power supplies shall be conditioned and not loaded more than 75% of rated capacity.

R. Integrated Boiler Controls.

1. Shall be BACnet compatible and interfaced to the BAS with sufficient capabilities to satisfy the control sequences of the equipment served.
2. Binary Values (BV) shall be provided for monitoring system status and fault indication.
3. Integration of systems to BAS for Class II circuits over 50 volts shall be provided by LED RIB Relays.
4. Each Rib Relay shall be clearly identified.
5. All integral internal and external safety circuits for Boiler protection shall be internal to Boiler controls. All safety circuit wiring shall be direct from safety devices to equipment controller.

S. Integrated Chiller Controls.

1. Shall be BACnet compatible and interfaced to the BAS with sufficient capabilities to satisfy the control sequences of the equipment served.
2. Binary Values (BV) shall be provided for monitoring system status and fault indication.
3. Integration of systems to BAS for Class II circuits over 50 volts shall be provided by LED RIB Relays.
4. Each Rib Relay shall be clearly identified.
5. All integral internal and external safety circuits for Chiller protection shall be internal to Chiller controls. All safety circuit wiring shall be direct from safety devices to equipment controller.

T. Integrated VFD' Controls.

1. Shall be BACnet compatible and interfaced to the BAS with sufficient capabilities to satisfy the control sequences of the equipment served.
2. Binary Values (BV) shall be provided for monitoring system status and fault indication.

3. Integration of systems to BAS for Class II circuits over 50 volts shall be provided by LED RIB Relays.
4. Each Rib Relay shall be clearly identified.
5. All integral internal and external safety circuits for connected equipment protection shall be internal to VFD controls.
6. For multiple motors powered from a single VFD, Manual Motor Starters and CT's shall be provided for each motor in an array and integrated into the VFD.

2.13 ENERGY MANAGEMENT SYSTEMS (EMS) SOFTWARE

A. The following Energy Management capabilities shall be furnished standard as part of the Building Automation System Panel.

B. Trend Log Application.
1. Trend log data shall be sampled and stored on the System Controller panel and shall capable of being archived to a BACnet Workstation for longer term storage.
2. Trend logs shall include interval, start-time, and stop-time.
3. Trend log intervals shall be configurable as frequently as 1 minute and as infrequently as 1 year.
4. The system controller shall automatically create trend logs for defined key measurements for each controlled HVAC device and HVAC application.
5. The automatic trend logs shall monitor these parameters for a minimum of 7 days at 15 minute intervals. The automatic trend logs shall be user adjustable.

C. Trend log shall be maintained for three years.

D. Optimum Start/Stop
1.
1. An optimum start/stop program shall determine the required equipment start/stop timing by applying inside/outside temperature information to the user's time of day schedule.
2. The optimum start/stop program shall run independently for each controlled load or zone.
3. The program shall automatically make adjustments to itself based on historical data, limited to 4 hours.

E. Alarm/Event Log.
1. Any object in the system shall be configurable to generate an alarm when transitioning in and out of a normal or fault state.
2. Any object in the system shall allow the alarm limits, warning limits, states, and reactions to be configured for each object in the system.
3. An alarm/event shall be capable of triggering any of the following actions: Route the alarm/event to one or more alarm log, route an e-mail message to an operator(s), Log a data point(s) for a period of time, Run a custom control program.

F. Chilled Water System. An operator shall be able to view and control (where applicable) the following parameters via the operator interface:
1. System mode of the chiller plant.
2. Chiller enable/disable status.
3. System supply water setpoint.
4. System supply and return water temperature for each chiller and circuit.
5. System Chilled water pump status for each chiller and circuit.
6. Operator description as to when an additional chiller will be added or removed from operational sequence.
7. Chiller or support system failure information.
8. Chiller pump, tower, rotation information.
9. Override capabilities to force an added chiller, subtract a chiller, or change of sequence.
10. Control to remove a chiller from a sequence temporarily for service purposes.

11. In addition to system flow graphics, provide a system operator information screen.

G. Variable Volume Air System. An operator shall be able to view and control (where applicable) the following parameters via the operator interface:
1. System Mode.
2. System Occupancy.
3. Space Temperature.
4. RTU/Air Handler Static pressure setpoint.
5. RTU/Air Handler Static pressure status.
6. RTU/Air Handler occupancy status.
7. RTU/Air Handler Supply air cooling and heating set points.
8. RTU/Air Handler minimum, maximum and nominal static pressure setpoints.
9. VAV box minimum and maximum flow.
10. VAV box occupancy status.
11. VAV box Airflow to space.
12. VAV box supply temperature (with coils)
13. Average space temperature.
14. Minimum space temperature.
15. Maximum space temperature.
16. Discharge air temperature.
17. Damper positions.
18. Unit mode.
19. Fan start/stop and status.
20. OA flow.
21. RA temp.

H. Air handling unit freeze stat(s) shall be identified, and factory mounted in a location readily accessible by the technician for operation and repair, with manual reset option only.

I. Duct Static Pressure Optimization must be application complying with ASHRAE 90.1-2010 energy saving requirements at a minimum, the screen shall display airflow graphics and duct pressure readings.

J. Demand Control Ventilation must be application complying with ASHRAE 62.1-2004 ventilation requirements. At a minimum, the screen shall display airflow graphics, CO2 readings, and OSA damper position.

K. Totalizing.
1. A totalizing program shall be provided to enable the building operator to monitor and totalize any user-defined flow such as water flow, electricity, and natural gas.
2. A minimum of 64 totalizing equations shall be provided.

L. Expanded Messages.
1. The user shall be able to define a minimum of ten 40 character messages for automatic printing in the event of system alarm and/or run time and maintenance events.
2. A minimum of 64 totalizing equations shall be provided.

M. Diagnostics.
1. The building operator shall be provided with a report containing common symptom and diagnostic trouble shooting guides for HVAC system equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that duct and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

A. Each equipment shall have a dedicated new DDC controller and must be mounted at respective equipment or in unit mechanical room for ease of maintenance.

B. Interlock wiring cable shall be white color or as coordinated with other trade not to conflict.

C. Smoke detector interlock shutdown wiring cable shall be red color or as coordinated with other trade not to conflict.

D. All DDC cabling shall be purple color with yellow stripe.

E. Interlock shutdown wiring shall be wired directly fail safe from the signaling device to the actuated equipment Integrated Controls and be supported at regular interval. The interlock shutdown signaling device shall also be wired fail safe to the BAS DDC controls.

F. All electrical work performed in the installation of the BAS/ATC system as described in this specification shall be per the National Electrical Code (NEC) and per applicable state and local codes. All wiring shall be installed in electric metallic tubing conduit except as allowed below. Where exposed, conduit shall be run parallel to building lines properly supported and sized at a maximum of 40 percent fill. In no cases shall field installed conduit smaller than ½ inch trade size be allowed. All electrical work shall comply with Electrical requirements of these specifications.

G. If not indicated on the electrical drawings to be provided by the Electrical Contractor, the Automatic Temperature Controls contractor shall be responsible for dedicated ATCS power to closest electrical panel that can support a 120 volt 20 ampere breaker.

H. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except where UL Listed for the purpose of interfacing the two (e.g. relays and transformers.)

I. All wire-to-device connections shall be made at a terminal blocks or terminal strip and clearly identified. All wire-to wire connections shall be at a terminal block. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

J. All wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device with each conductor clearly identified.

K. Size of conduit and size and type of wire shall be the design responsibility of the Control System Contractor, in keeping with the manufacturer's recommendation, CMS color code and NEC.

L. Control and status relays are to be located in designated enclosures only. These relays may also be located within packaged equipment control panel enclosures. These relays shall not be located within Class 1 starter enclosures unless UL Listed for the purpose.

M. Adhere to Electrical requirements for installation of raceway.

N. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3 feet in length and shall be supported at each end. Flexible metal conduit less than ½ inch electrical trade size shall not be used.

O. Mount laminated controls drawings and operational sequences next to the main controller.

P. Mount the panel specific labelled wiring diagrams inside the main controller. Provide specific termination labeled wiring diagram for each controller. Laminate and adhere to the inside of each individual panel door.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Electrical requirements.

B. Install building wire and cable according to Electrical requirements Section "Control-Voltage Electrical Power Cables."

C. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

D. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

E. Provide laminated engraved tags for every box and cabinet containing devices, controllers, transformers, or equipment.

F. Identify raceway junction box covers containing Network Cables with the color purple.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test each point through its full operating range to verify that safety and operating control set points are as required.
4. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
5. Test each system for compliance with sequence of operation.
6. Test software and hardware interlocks.
7. Provide seasonal testing while building is occupied in August/September for cooling mode, and December/January for heating mode.
8. Inspect all field equipment for proper DDC tagging wire identification and labeling.

C. DDC Verification:
1. Verify that instruments are installed before calibration and testing.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

4. Check temperature instruments and material and length of sensing elements.
5. Check DDC system as follows:
   a. Verify that DDC controller power supply is from emergency power supply, if applicable.
   b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
   c. Verify sequence of operation functional performance.
6. Verify that the systems control, and sequence of operations can be accessed from the graphical interface via the embedded pdf. File per specification section 230901.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:
   1. After completion of the installation, perform final checkout and adjustments of the equipment provided under this contract and supply services incidental to the proper performance of the ATC and BAS system under warranty below.
   2. Adjust initial temperature and other set points.
   3. See sequence of operation for initial temperature/pressure setpoint values.

B. Provide final time schedule programming during Owner's training.

3.6 INTEGRATION OF NON-HVAC BUILDING SYSTEMS

A. See Sequence of Operation section 23 09 93 for miscellaneous integration or monitoring requirements to be connected to BAS.

B. HVAC equipment, generators, and electrical smart meters shall be provided with protocol capability as stated in Sequence of Operation section 23 09 93. The work to provide, install, and valid functions of these system shall be provided by the Division 26 Electrical Contractor. The Division 26 Electrical Contractor shall provide the objects points list to the BAS contractor so integration to BAS.

C. The work to provide, install, and validate functions of the lighting system shall be provided by the Division 26 Electrical Contractor.

D. All the classrooms, offices, storage rooms, and similar spaces will have vacancy sensors which will turn the lights off automatically. All other spaces (hallways, corridors, gym, locker rooms, cafeteria, multipurpose room, electrical & mechanical rooms, and similar spaces) having manual switches will not have occupancy sensors and will be scheduled and controlled by the Building Automation System (BAS). The BAS lighting control shall be on a separate schedule from the HVAC.

E. Lights will be zoned into logical areas, each controlled by a zone contactor. An output from the BAS drives each zone contactor and is wired in a fail-safe manner that causes the lighting contactors to close (normal state) if any part of the BAS fails.

F. Provide output signal to each electrical room with a lighting panel for lighting control through the BAS. There will be an override bypass switch/timer for each lighting zone (electrical room). To accommodate school activities that may occur outside these hours, a bypass timer will be provided by the Electrical Contractor for each lighting zone. These timers will provide an input to the BAS while they are timing and have a maximum setting of 4 hours. They will be grouped at the front office. If a timer is activated, it will bypass the normal time schedule for the set hours and close the lighting contactor. When the timer times out, it will cause the contactor state to revert to whatever is specified in the time base. Five minutes before the timer is to time out, it will cause the contactor to drop out for an instant as a warning that if additional time is desired, the timer needs to be reset. Controls Contractor to provide and install low voltage wiring from timers to BAS.

G. There shall be a burglar alarm override of the BAS lighting control.

H. Provide input to the BAS indicating when the security system is armed. If the input is ON, the building is assumed to be unoccupied and the contactors are opened immediately regardless of the state of the normal time base or the bypass timers. If the security system is unarmed, the contactors revert to whatever state is called for by the time base or bypass timers. Controls Contractor to provide and install wiring from the security panel to the BAS.

I. The Controls Contractor shall provide zone contactors. The Electrical Contractor will provide the lighting contactors. See Electrical Drawing Details for Interior Lighting Control Wiring Diagram.

J. An ON-OFF-AUTO switch will be provided by the Electrical Contractor. The Controls Contractor shall wire the switch to interface to the BAS to function as follows:
1. AUTO: BAS control of lights. Enabled with burglar alarm and bypass switch/timer overrides enabled.
2. ON: BAS control of lights enabled with burglar alarm and bypass switch/timer overrides disabled.
3. OFF: BAS control of lights disabled with burglar alarm and bypass switch/timer overrides disabled. Lights under local switch control only.

K. The Controls Contractor shall demonstrate an operational lighting control system to the owner upon completion of the project. Demonstration shall include the following:
1. BAS time based control of ON/OFF
2. Security override of time based control. Check armed and unarmed state.
3. Bypass switch/timer functionality.
4. ON-OFF-AUTO switch/timer function.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's Energy Management Staff (PM's and EMS Control Specialists) in two phases. to adjust, operate, and maintain HVAC instrumentation and controls. Provide a site walk-thru to view the layout and placement of the EMS/BAS System controllers, equipment controlled, integration to equipment, and sensor locations as marked. Provide 24 hours of technical classroom training of the BAS Vendor's system "live," on site or another suitable location to be determined by CMS over a multi-day/week time period. The agenda will be defined to include remote access to the completed project's GUI, exercises using diagnostics utilizing all the software and hardware capabilities of the BAS, programming, graphical editing, editing/addition of tags, labels and hyperlinking of points and pdf's.

3.8 SPARE PARTS LIST

A. Controls contractor shall provide spreadsheet bill of materials for each specific component used on the project. Spreadsheet shall be provided as a hyperlink on the BAS front end.

3.9 WARRANTY REQUIREMENTS

A. TWO-YEAR WARRANTY: Provide all labor, material, and equipment necessary to maintain beneficial performance of the entire control system for a period of two (2) years after DELIVERY OF THE COMPLETED FLAWLESS GRAPHICAL USER INTERFACE as accepted by no less than two EM/EMS staff members. The controls subcontractor at no charge to the Owner shall promptly correct any defects in workmanship or material during the warranty period. All work shall be accomplished during normal working hours M-F if possible. Precaution shall be taken to minimize disruption of facility operations.
1. Provide an alternate price to extend this warranty to five (5) years.

END OF SECTION 230900